Attachment 6 – Monitoring, Assessment, and Performance Measures

Project A: Fresno ID – Southwest Groundwater Banking Project

The Monitoring, Assessment and Performance Measures (MAPM) identified for this project are similar to the MAPM and Performance Assessment and Evaluation Plans (PAEP) prepared for other similar groundwater recharge and banking projects that the Kings Basin Water Authority (Authority) has completed with DWR. A ground water monitoring program will be put in place that consists of District staff recording monitoring well levels and flow measurement in order to track recharge and recovery operations, groundwater levels and groundwater quality along the McMullin Grade Canal. A network of monitoring wells, flow measurement at individual turnouts, and recovery wells will be monitored so that a complete water balance can be estimated for the project site.

An annual monitoring report will be developed for the project, similar to those prepared for other similar banking projects. A copy of a recent similar report that will be used as a template for this project is included as **Attachment 6a**.

This monitoring will help in determining the following parameters:

1) Determine long-term recharge rate for the facility;
2) Evaluate the effect of groundwater recharge on shallow groundwater levels beneath and adjacent to the facility;
3) Determine drawdown during recovery well pumping in zones tapped by nearby water supply wells;
4) Evaluate development of operation and maintenance procedures to maintain or enhance recharge rates;
5) Evaluate need for measures to increase recharge rates, should long-term rates be found inadequate;
6) Evaluate need for measures to reduce groundwater mounding should it be found to adversely affect properties or public facilities adjacent to the facility;
7) Determine measures to limit drawdown in water supply wells within the area as needed;
8) Evaluate the ability to monitor project operations and to allow controls so that the project accomplishes the goals of developing additional water supplies while not negatively affecting neighboring landowners;
9) Evaluate effect of groundwater recharge on local groundwater quality.

The monitoring facilities described below will be included in the Project Plans:

Monitoring wells. A monitoring network of wells will be established in an around the project, including wells upgradient and downgradient of the basin and extraction wells.

Flow meters (Inlet Pipe). Propeller flowmeters will be installed at the basin turnouts. These meters will be similar to other measurement methods within the District and will measure water deliveries to the recharge basin within +/- 2% based on manufacturer's information. The existing flow meter at the point where the Lower Dry Creek Canal into McMullin Grade will be used to measure any surface water conveyed directly to James ID. James ID will utilize existing flow meters at its basins to measure the amount of surface water delivered.

Flowmeters (Wells). Propeller flow meters on the extraction wells will used to measure the water pumped and delivered to McMullin Grade Canal. The meter will measure flows that are released from the basin with an accuracy of +/- 2%. Water will be released if it is temporarily stored and later delivered to irrigators. This pipe may also be used for emergency releases in case the basin is overtopping, levee stability is compromised, etc.

Staff gauges. A staff gauge will be installed in the basin to monitor water levels. These will be used to assist with operations and help to monitor long-term recharge rates.

Performance measures will include the following:

Volume Recharged. The volume of water recharged will be equal to the volume diverted into the recharge basin minus evaporation losses. Evaporation losses are expected to be small since they will be partially offset with direct precipitation onto the basin, and much of the recharge will be performed in the winter and spring when evaporation rates are not high.

Increase in Groundwater Levels. Groundwater levels will be monitored in the wells in the monitoring network. This data will be used to determine the change in groundwater storage and rate of groundwater outflow from the area. Improvements in groundwater storage would also be evident in the accumulated groundwater monitoring efforts within the Kings Basin (KRCD's monitoring network, CASGEM, irrigation district monitoring efforts, etc.).

Maintenance of Recharge Rate. The recharge rate will be measured using staff gauges and accounting for new deliveries, outflow and evaporation losses. The success in maintaining the recharge rate with use of the settling channel and annual ripping/disking will also be evaluated with this parameter.

Improvement in Groundwater Quality. Groundwater quality will be periodically tested in the wells in the monitoring network. Groundwater quality monitoring will also be required under the pending Long Term Irrigated Lands Regulatory Program. These monitoring programs could potentially show the improvements in groundwater quality from the introduction of large volumes of Kings River water.

Performance measure used to qualify and quantify are described in Table 6-1.

Table 6-1 Project A FID Southwest Groundwater Banking Project Monitoring Assessment and Performance Measures					
Project Goals	**Desired Outcomes**	**Output Indicators**	**Outcome Indicators**	**Measurement Tools and Methods**	**Targets**
Expand the available water supply to the Kings River region	Bank water to provide an additional annual water supply average of 5,500 AF	Amount of water pumped and extracted using the banking facility recovery wells	Project completion and evaluation of operations	Meters installed on all recovery wells, annual exchange of water supply based on pumpage amount in accordance water transfers/sales	Create 5,500 AF additional average annual water supply
Make use of the portion of Kings River floodwater and fishery water that is lost to FID, JID, and the Kings River region	Utilize surface water supplies during the irrigation season that is usually only available to FID and JID during low demand periods of the year	Completed project. Amount of water diverted and recharged at the site	Measurement of water diverted into project basins	Meters installed at recharge facilities and turnouts, documentation of water supplied to facility	Bank an average of 5,500 AF per year
Maintain and Improve Groundwater Quality near the project	Sustained and Improved Water Quality within the Project Recharge and Groundwater Pumping Areas	Groundwater Quality has maintained or improved.	Groundwater Quality	Quarterly to Annual Groundwater (& Surface Water) Quality Monitoring and Testing. Results included in annual operations report	Sustained and improved groundwater quality. Lower EC groundwater.
Increase groundwater storage	Provide recharge capacity to provide additional storage	Completion of recharge facilities	Groundwater levels in the project vicinity	Groundwater monitoring with onsite monitoring wells to identify mounding and available storage.	Up to 5,000 AF of additional annual extractable groundwater storage

Table 6-1 Project A FID Southwest Groundwater Banking Project Monitoring Assessment and Performance Measures					
Project Goals	**Desired Outcomes**	**Output Indicators**	**Outcome Indicators**	**Measurement Tools and Methods**	**Targets**
Provide a reliable, dry year water supply	Bank water to provide an additional annual water supply average of 5,500 AF	Amount of water pumped and extracted using JID's existing recovery wells	Project completion and evaluation of operations	Meters installed on all recovery wells, annual exchange of water supply based on pumpage amount in accordance water transfers/sales	Create 5,500 AF additional average annual water supply, available during dry years
Reduce local groundwater overdraft	Reduction in groundwater overdraft in the Raisin City groundwater depression region and maintain groundwater levels	Amount of water recharged, recovered, exchanged	Groundwater levels in project vicinity	Groundwater monitoring using the proposed monitoring well canvass to identify mounding and available storage	10% of banked water will be considered recharged into aquifer, lost from banking operations
Sustain the local agricultural community by providing revenue to FID and JID	Completed project generating revenue by future water sales and transfers, funding to construct additional banking projects and subsidize water costs to FID and JID customers.	Quantity of water sold, operational costs	Amount of revenue generated from water sales	Meters installed on all recovery wells, annual exchange of water supply based on pumpage amount in accordance water transfers/sales	Additional operating revenue over and above operational/ sales costs
Minimize flooding damage by diverting some floodwaters	New facilities that can divert floodwaters and thereby reduce the potential for flood related damage downstream of the project site and downstream of FID's Kings River diversions	New facilities capable of diverting and recharging water including turnouts, and basin improvements	Volume of floodwater diverted and recharged each year	Water measurement facilities on project turnouts	Divert and bank long term average of 5,500 AF per year, utilizing available Kings River floodwater and fish flows

Table 6-1 Project A FID Southwest Groundwater Banking Project Monitoring Assessment and Performance Measures					
Project Goals	**Desired Outcomes**	**Output Indicators**	**Outcome Indicators**	**Measurement Tools and Methods**	**Targets**
Increase knowledge of the local geology and hydrogeology	Gain new information of performance of facility and design improvements	Completion of recharge facilities	Monitoring groundwater levels in the project vicinity, infiltration rates	Groundwater monitoring of adjacent wells to identify mounding and available storage	New knowledge of project area, and application for development in other areas

Project B: Laguna Irrigation District Recharge Basin 11

The MAPM identified for this project are similar to the MAPM and Performance Assessment and Evaluation Plans (PAEP) prepared for other similar groundwater recharge and banking projects that the Kings Basin Water Authority (Authority) has completed with DWR. Monitoring, assessment and performance measures for the project are described below. The monitoring facilities described below are illustrated on the Project Map in Attachment 3 – Work Plan:

Monitoring wells. Four 100-feet deep monitoring wells will be installed for the project. These include one on the west (groundwater downgradient), east (groundwater upgradient), and north side of the basin. One additional monitoring well is proposed in the area of LID not receiving surface water.

Flow meters (Inlet Pipe). A propeller flowmeter will be installed in each of the two 48-inch diameter inlet pipes. The meters will measure water deliveries to the recharge basin within +/- 2% based on manufacturer's information

Flowmeters (Outlet Pipe). A propeller flow meter will be installed in the outlet pipe to Murphy Slough. The meter will measure flows that are released from the basin with an accuracy of +/- 2%. Water will be released if it is temporarily stored and later delivered to irrigators. This pipe may also be used for emergency releases in case the basin is overtopping, levee stability is compromised, etc.

Staff gauges. Two staff gauges will be installed in the basin to monitor water levels. These will be used to assist with operations and help to monitor long-term recharge rates.

Performance measures will include the following:

Volume Recharged. The volume of water recharged will be equal to the volume diverted into the recharge basin from Liberty Canal minus evaporation losses. Evaporation losses are expected to be small since they will be partially offset with direct precipitation onto the basin, and much of the recharge will be performed in the winter and spring when evaporation rates are not high.

Floodwater Diverted. Floodwater diverted will be equal to the volume of Kings River and San Joaquin River floodwater diverted into the basin. This will reduce floodflow peaks in downstream river sections. In most years, this parameter will be the entire volume diverted to the project.

Increase in Groundwater Levels. Groundwater levels will be monitored in new dedicated monitoring wells and other wells in the vicinity. This data will be used to determine the change in groundwater storage and rate of groundwater outflow from the area. Improvements in groundwater storage would also be evident in the accumulated groundwater monitoring efforts within the Kings Basin (KRCD's monitoring network, CASGEM, irrigation district monitoring efforts, etc.).

Volume Regulated. The volume regulated will be equal to the volume of water temporarily stored in the reservoir, and diverted through the outlet structure to Murphy Slough. This water volume will be measured with propeller meters.

Maintenance of Recharge Rate. The recharge rate will be measured using staff gauges and accounting for new deliveries, outflow and evaporation losses. The success in maintaining the recharge rate with use of the settling channel and annual ripping/disking will also be evaluated with this parameter.

Improvement in Groundwater Quality. Groundwater quality may be periodically tested in the four dedicated monitoring wells. Groundwater quality monitoring will also be required under the pending Long Term Irrigated Lands Regulatory Program. These monitoring programs could potentially show the improvements in groundwater quality from the introduction of large volumes of Kings River water.

Performance measure used to qualify and quantify are described in Table 6-2.

Table 6-2 Project B Laguna ID Recharge Basin 11 Project Monitoring Assessment and Performance Measures					
Project Goals	**Desired Outcomes**	**Output Indicators**	**Outcome Indicators**	**Measurement Tools and Methods**	**Targets**
Expand the available water supply to the Kings River region	Bank water to provide an additional annual water supply average of 2,650 AF	Amount of water diverted into recharge basin	Project completion and evaluation of operations	Meters installed on turnout to recharge basin	Create 2,650 AF additional average annual water supply
Increase groundwater storage	Provide recharge capacity to provide additional storage	Completion of recharge facilities	Groundwater levels in the project vicinity	Groundwater monitoring with onsite monitoring wells and regional monitoring programs to identify mounding and available storage.	Up to 10,000 AF of additional extractable groundwater storage
Maintain and Improve Groundwater Quality near the project	Sustained and Improved Water Quality within the Project Recharge and Groundwater Pumping Areas	Groundwater Quality has maintained or improved.	Groundwater Quality	Quarterly to Annual Groundwater (& Surface Water) Quality Monitoring and Testing. Results included in annual operations report	Sustained and improved groundwater quality. Lower EC groundwater.
Provide a reliable, dry year water supply	Recharge water to provide an additional annual water supply average of 2,650 AF	Amount of water diverted into recharge basin	Project completion and evaluation of operations and increases in groundwater levels	Groundwater monitoring using the proposed monitoring wells and regional monitoring programs	Create 2,650 AF additional average annual water supply, available during dry years

Table 6-2 Project B Laguna ID Recharge Basin 11 Project Monitoring Assessment and Performance Measures					
Project Goals	**Desired Outcomes**	**Output Indicators**	**Outcome Indicators**	**Measurement Tools and Methods**	**Targets**
Reduce local groundwater overdraft	Reduction in groundwater overdraft in LID and project vicinity and maintain groundwater levels	Amount of water recharged in the basin	Groundwater levels within LID and project vicinity	Groundwater monitoring using the proposed monitoring wells and regional monitoring programs	Recharge 2,650 AF/year
Minimize flooding damage by diverting some floodwaters	New facilities that can divert floodwaters and thereby reduce the potential for flood related damage downstream of the project site	New facilities capable of diverting and recharging water including turnouts, and basins	Volume of floodwater diverted and recharged each year	Water measurement facilities on project turnouts	Divert and bank long term average of 2,650 AF per year and up to 70 cfs at a time, utilizing available Kings River floodwaters
Increase knowledge of the local geology and hydrogeology	Gain new information of performance of facility and design improvements	Completion of recharge facilities	Monitoring groundwater levels in the project vicinity, infiltration rates	Groundwater monitoring of adjacent wells to identify mounding and available storage	New knowledge of project area, and application for development in other areas

Project C: Bakman Water Supply Reliability and Conservation Project

The MAPM identified for this project are similar to the MAPM and Performance Assessment and Evaluation Plans (PAEP) prepared for other similar projects that the Kings Basin Water Authority (Authority) has completed with DWR. Project Performance Measures for the proposed project will include ongoing monitoring efforts that will be used to demonstrate the project performance. The objectives of the Monitoring, Assessment, and Performance Measures are to provide Bakman with documented information that will allow Bakman to evaluate the effect of installing water meters on the water usage within the water service area and the quality and quantity of water made available by installation of the treatment and blending infrastructure.

Treatment and Blending Process

As a component of the treatment and blending process, the water will sampled and tested for constituent to ensure it is meeting drinking water standards. Additionally, the wells are equipped with meters to monitor the additional supply being made available to the community through construction of the project. The project includes SCADA monitoring to allow for prompt response and reaction to changes within the water quality.

Meter Reading Program

The meter reading program will monitor water usage throughout the service area. Bakman will use existing data of water consumption to compare with the consumption after meters are installed to determine how much water is being conserved. They will also analyze daily meter readings to examine daily, weekly, and annual fluctuations in consumption rates in order to more efficiently manage the water system.

Other

One of the project goals is to slow the movement of contaminant plumes in the project area. While this is a real concern, it is not measureable. Several of Bakman's wells have already been affected by contaminants such as Dibromo-Chloropropane (DBCP) and nitrates, and there are additional contaminant plumes in the area that could eventually affect Bakman's groundwater supply quality (see Attachment 7). Routine water quality monitoring will continue in accordance with requirements of the California Department of Public Health. Additionally, by conserving water through reducing usage, this project will help halt overdraft in the region. The impact on overdraft of the groundwater will be directly related to the decrease in consumption, and therefore will be measured through the meter reading program. Additional groundwater level monitoring will not be necessary.

Performance measure used to qualify and quantify are described in Table 6-3.

Table 6-3 Project C Bakman Water Company Water Supply Reliability and Conservation Project Monitoring Assessment and Performance Measures					
Project Goals	**Desired Outcomes**	**Output Indicators**	**Outcome Indicators**	**Measurement Tools and Methods**	**Targets**
Re-Initiation of Nitrate Blending Plan at Well 8 that was suspended when DBCP exceeded the MCL.	Well 8 operational, providing suitable water quality	Completed project, water quality standards met	Project Complete and operational	Water Quality testing and successful operation of well 8	Operation of well 8 to augment DAC system with limited available suitable supply in aquifer with multiple contamination concerns.
Provide Nitrate Blending to reduce water production from Well 8 below MCL	Groundwater from Well 8 below Nitrate MCL	Nitrate levels in Groundwater pumped from Well 8	Volume and frequency of water pumped from well 8 below Nitrate MCL	Nitrate Analyzer, SCADA system recording data, and water quality testing to compare current nitrate levels to historic levels and the MCL	Bring water from Well 8 below Nitrate MCL
Provide Wellhead Treatment for DBCP	Groundwater from Well 8 below DBCP MCL	Nitrate levels in Groundwater pumped from Well 8	Volume and frequency of water pumped from well 8 below Nitrate MCL	SCADA system recording data, and water quality testing to compare DBCP levels after operation to prior to operation	Bring water from Well 8 below Nitrate MCL
Conserve the potable water supply by reducing water usage by 20% with the completion of metering their system by 2015.	Reduce water use by 20%.	Total annual groundwater pumped	Number of acre-feet of water conserved	Tool: System Water Use Records Method: Compare annual water use before and after project completion.	Reduce groundwater consumption by 20%, 869 acre-feet per year once metered rate is in place.
	Reduce residential consumption	Number of residential meters installed	Residential per capita per day water use rate	Tool: System Water Use Records Method: Compare 2010 UWMP Update water use baseline (275gpcd) to baseline after project completion.	Reduce residential per capita use to 233gpcd once metered rate is in place.

Bakman Water Company will increase redundancy in their supply system and increase the quality of water delivered by construction of treatment and blending infrastructure.	Increase drinking water capacity within the service area	Water quality sampling results and well meter data	Sampling results under all MCLs once the supply is treated and blended for consumption; supply capacity increased	Tool: Sampling Results and Meter Data Method: Compare pre-project sampling results and supply capacity to post-project	Increase supply capacity and additional safe drinking water by approximately 432,000gpd.

Project D: San Joaquin Water Supply Reliability and Conservation Project

The MAPM identified for this project are similar to the MAPM and Performance Assessment and Evaluation Plans (PAEP) prepared for other similar projects that the Kings Basin Water Authority (Authority) has completed with DWR. Project Performance Measures will include monitoring of the project to verify project performance with respect to the project benefits or objectives identified in the Proposal.

Performance testing on well rehabilitation will be conducted to ensure suitable water supply is generated and water quality standards are met. The well will be subject to standard CDPH testing requirements for operation within the system. The testing will include E.Coli and total coliform to ensure satisfactory levels are met. The City will also include the well to its standard water quality testing for other existing wells, including constituents of concern in the area such as arsenic (currently testing every 3 years), manganese (quarterly), VOCs, SOCs, gross alpha, and bacterial sampling. The City will also comply with the Bacteriological Sample Siting Plan (BSSP) and the requirements of the June 14, 2011 CDPH Memo (**Attachment 7j**).

City Staff will monitor the water meters by collecting regular meter readings and recording usage in the meter reading software. Residents will be provided an opportunity to use the meters at a flat rate for a designated time period during which time the City will provide its residents educational opportunities for water conservation practices and devices. Residents will receive bills at the current flat rate for a designated period of time while education takes place. City staff will monitor this through the billing process and data provided daily through the installed smart meters. Evidence of leaks and overuse will be followed up by City Staff, similar to a City practice that already takes place. The City will not tolerate disabling or destruction of meters, and will implement policies to enforce this position.

Once billing based on water use is implemented, City staff will continue to monitor resident water use practices. The City currently analyzes water use and will continue to do a monthly analysis of water use. The intent is to see a reduction in the water use, thereby an anticipated reduction in overdraft of ground water. Annual monitoring of the effect of water meters will be conducted as well.

Performance measure used to qualify and quantify are described in Table 6-4.

Table 6-4 Project D City of San Joaquin Water Supply Reliability and Conservation Project Monitoring Assessment and Performance Measures					
Project Goals	**Desired Outcomes**	**Output Indicators**	**Outcome Indicators**	**Measurement Tools and Methods**	**Targets**
Rehabilitation Well 4 and put back into operation	Well 4 operational	Completed project, water quality standards met	Project Complete and operational	Water Quality testing and successful operation of well 4	Operation of well 4 to augment DAC system with inadequate supply to meet fire flow requirements
Increase system capacity to meet fire flow requirements and peak flow when one well is out of service	Well 4 operational, providing 1,000gpm or more to system	Well 4 operational flowrate	Flowrate, operational well	Flow measurement at well using flow meter	1,000 gpm added back into system
Well rehabilitation to eliminate bacteriological concerns	Operational well without E.Coli and total coliform concerns	Suitable water quality	Test results showing satisfactory water quality levels	Bacteriological testing for E. Coli, and total coliform	Total Coliform including E. Coli below MCL
Promote Water Conservation	Save 20% of current residential water usage	20% of water conserved	Analyses and evaluation of historic groundwater pumping vs. pumping after implementation of meter project	Record water usage from customers as well as from well sites	Install approximately 644 residential water meters.

Table 6-4 Project D City of San Joaquin Water Supply Reliability and Conservation Project Monitoring Assessment and Performance Measures					
Project Goals	**Desired Outcomes**	**Output Indicators**	**Outcome Indicators**	**Measurement Tools and Methods**	**Targets**
Reduce local groundwater overdraft	Reduction of groundwater overdraft in City.	Estimate 159 acre-feet of water conserved each year	Groundwater levels within City	The City will analyze existing data on the amount of water pumped from City wells, project savings and the estimated resulting reduction in overdraft	Reduction of overdraft by 159 AF per year

Project E: City of Kerman Residential Water Meter Project

The monitoring, assessment, and performance measures for work completed within contract area will be accomplished through acceptance testing of project components prior to, and after installation. The contractor will be responsible for system performances through warranties and 'system performances guarantees' after installation (i.e. the meter transponders will all be 100% functional and 98% accurate) at each location. Through these contractor requirements, and results obtained through the integration the project with the 'overall' project monitoring system, comparative evaluations can be made related to project area's performance. Results from residential water meter AMR systems will provide an avenue for assessing original IRWMP and project goals for achieving a net reduction of annual water use across the project's newly water metered customers, and reducing local area groundwater overdraft conditions.

These results will quantify anticipated project benefits through additional outcome indicators including; 1) expectations based on similar projects and the per capita water use of those residences in the City currently metered, 2) comparative analysis of metered quantities to historic monthly and annual groundwater pumping volumes for the overall project and those within contract area, 3) address of the groundwater overdraft conditions by long-term monitoring well evaluations.

Performance measure used to qualify and quantify are described in Table 6-5.

Table 6-5 Project E City of Kerman Residential Water Meter Project Monitoring Assessment and Performance Measures					
Project Goals	**Desired Outcomes**	**Output Indicators**	**Outcome Indicators**	**Measurement Tools and Methods**	**Targets**
Conserve the potable water supply by reducing water usage by 20% with the completion of metering their system by 2015.	Reduce water use by 20%.	Total annual groundwater pumped	Number of acre-feet of water conserved	Tool: System Water Use Records Method: Compare annual water use before and after project completion.	Reduce groundwater consumption by 20%, 162 acre-feet per year once metered rate is in place.
	Reduce residential consumption, promote conservation	Number of residential meters installed	Residential per capita per day water use rate, leak detection monitoring	Tool: System Water Use Records Method: Compare 2010 UWMP Update water use baseline to baseline after project completion.	Reduce residential per capita use
Aquifer protection, groundwater storage	Sustain the groundwater aquifer levels	Groundwater levels	Depth to groundwater in wells	Twice annual groundwater level readings in wells and compare to historic groundwater levels	Reduced rate of drop in groundwater levels